PLANT MATERIALS FOR RIVER TRAINING

AND BANK PROTECTION

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INTRODUCTION

The most effective means of controlling streambank erosion is usually to establish a vegetative cover of strongly rooting plants. Vegetation contributes to bank stability by retarding water speeds and tractive forces near the soil surface and buffering transported materials such as logs away from banks. In addition, the reinforcing and soil-binding action of the roots provide a considerable degree of cohesion to soils. The indirect benefits which favour a vegetative approach to soil erosion control include: reduction in nutrient and fine sediment enrichment; shade, shelter and filtering qualities for the aquatic eco-system; and aesthetic and recreational value.

This paper attempts to draw together information from a number of different sources to demonstrate the utility and effectiveness of vegetation in the regimen of rivers and streams. Special reference will be made to the tree, shrub and herbaceous species commonly used in New Zealand for river improvement work.

THE APPROACH TO RIVER IMPROVEMENT IN NEW ZEALAND

The rapid expansion of the agricultural frontier in New Zealand has had a profound impact on the condition of rivers and their immediate environs. By converting tussock and forest lands to pastoral grasses, and by introducing grazing animals and intensive land management practices, man accelerated the erosive forces of water and wind. The resulting sudden change in the character and quantity of erosion debris entering rivers and streams have since led to increased levels of siltation, bank erosion and flooding. In addition, runoff from agricultural land has produced undesirable eutrophication of rivers and lakes, and national development and urbanisation have created assets and communities vulnerable to floods and river erosion.

From the earliest days of European settlement and agriculture, in New Zealand man has struggled with the problem of soil -erosion. The earliest concern was the periodic inundation of lowlands with water, silt and gravels. This prompted local river boards or trusts (initially constituted under the River Boards Act 1884) to carry out flood and erosion prevention works. However, without a "catchment approach to soil erosion and siltation, the efforts of the River Boards foundered.

The first comprehensive legislative provision for soil conservation in New Zealand, the *Soil Conservation and Rivers Control Act 1941,* was initiated after catastrophic floods brought increased public awareness of the problems of soil erosion. This Act was very significant in New Zealand history as it provided for the constitution of catchment districts and catchment boards - thirteen catchment districts and one soil conservation district were subsequently formed. Catchment boards were empowered to coordinate preventative and remedial soil conservation measures with river improvement work within each catchment district.

Numerous legislative changes affecting river control work have been made since 1941, the most recent being the *Resource Management Act 1991.* This act will institutionalise a relatively new philosophy in New Zealand society - environmental management - and will set in place national minimal environmental standards. In respect of river improvement, it will enable various organisations, such as Fish and Game Councils, to become more influential in the formulation of river management strategies. As a result, future river management plans will require greater emphasis on multiple use principles, such as intrinsic eco-system values.

WILLOWS

The genus *Salix* is mostly found in northern hemisphere temperate areas. Willows are characteristically associated with sites that are subject to some form of physical disturbance; for example, river flood plains, gravel outwash plains, glacial moraines and sites of human disturbance (Argus 1973). These sites also tend to be cool and wet. Because of their vitality, advanced dispersal adaptations, and tolerance of a wide range of climatic and edphatic conditions, willows have flourished under New Zealand's moist temperate climate.

The first willow introductions in 1840 and 1869 included species such as *Salix fragilis* (crack willow), *S. alba* var *vitellina* (golden willow) and *S. viminalis.* Initially these willows were planted to provide a readily available source of firewood, but were subsequently used extensively to safeguard riverbanks from erosion. By 1914, 15 willow species and varieties were available in New Zealand. In 1937 a large importation from the Royal Botanic Gardens at Kew increased these to over 50. Since then the number of willow varieties that have been brought into the country has increased fourfold.

The geographical expansion of willows along New Zealand's rivers and streams was so rapid that, by the early 1950s, willow spread was out of control in many lowland areas. Their spontaneous reproduction along river beds was a serious problem, causing many channel diversions and blockages. Large sums of money are now spent eradicating these unwanted willows.

Willow breeding and selection work carried out by the Conservation Plants, DSIR Fruit and Trees (formerly the National Plant Materials Centre) at Aokautere, near Palmerston North has over the last 20 years made available a wide range of improved tree and shrub willow clones well suited for river control planting. The main selection criteria for the shrub and osier clones have been vigorous growth rate, flexible stems, male sex to prevent seeding, and bitter tasting foliage unpalatable to possums. Important selection criteria in the tree willow breeding programme include rapid growth rate, resistance to disease, straight stem form, strong root system with many fibrous roots, and male sex.

Shrub willow clones selected bank protection work include:

Salix purpurea 'Booth' (Booth willow) (PMC Accession No. 249)

This female osier willow has been widely planted for streambank protection and gully control. It has a multi-branched canopy and moderate growth rate. Its maximum height is approximately 7 m. Leaves are resistant to browsing by possums. The clone is sterile and will not set seed.

Salix purpurea 'Eugenii' (PMC Accession No. 239)

Introduced from England, this multi-stemmed clone has an upright habit and a vigorous growth rate. It will probably reach a height of 8 meters. Coppice regrowth from this clone is excellent. It is a male clone, and is resistant to browsing by possums.

Salix purpurea 'Holland' (PMC Accession No. 605)

Introduced from Holland, this male osier willow is in many respects similar to *S. purpurea* 'Booth'. Coppice growth is fast with up to 1.5 m of height growth per year. Branches are quite flexible, but wind damage has occurred in taller shrubs. It is resistant to browsing by possums.

Salix purpurea 'Irette' (PMC Accession No. 608)

Selected in France, this osier willow has an upright habit and will reach a maximum height of 7-8 m. Coppice growth is erect and vigorous, with over 2.0 m of height growth per year. It has been found to grow well at higher altitudes, provided sufficient soil moisture is available. It is a male with very bitter tasting foliage.

Salix purpurea 'Pohangina' (NZ 1087)

This male clone was selected at the Soil Conservation Centre, Aokautere. It has a moderately spreading habit with very vigorous, slender flexible stems. Maximum height is approximately 7 m. It is resistant to browsing by possums.

Salix elaeagnos x daphnoides ‘Tiritea' (NZ 1012)

This hybrid osier clone, also selected at the Soil Conservation Centre, Aokautere, is slightly less vigorous than the *S. purpurea* clones (maximum height is 4-7 m). It will not tolerate conditions of low soil moisture availability. Leaves have a high salicin content, and are resistant to browsing by possums. Sex is male.

Salix repens x purpurea 'Kumeti' (NZ 1057)

This hybrid clone was selected at the Soil Conservation Centre, Aokautere. The clone develops a semi-prostrate habit, with many horizontal branches. It has a maximum height of only 2-3 m. It is suitable where low ground cover is required. Sex is male.

S. glaucophyllodies x viminalis 'Glenmark' (CM 4)

A mixture of 8 clones, all large multi-stemmed spreading shrubs, reaching a maximum height of 6-8 m. This variety has been found to grow well under high country conditions in the South Island. Leaves are reasonably unpalatable to possums.

Unless the site specially requires large trees, the above shrub willows should be planted. Their advantages include:

> small maximum height, which lessens the maintenance required to keep them to a manageable height; fibrous root mat, which increases the resistance of soil to erosion;
>
> multi-stemmed bushy habit, which greatly reduces water velocity near the soil surface, encouraging siltation;
>
> tough but pliant shoots, which act as skid surfaces for large transported materials as they are deflected by the banks of the streams; bitter tasting foliage, which is unpalatable to rabbits, hares and possums.

Tree willows have been used extensively in New Zealand for riverbank planting. They are excellent trees for anchored tree protection work, mattress work, retards, groynes and stake planting (useful information concerning these methods is contained in the Plant Materials Handbook for Soil Conservation, Volume: 1 Principles and Practices).

Salix matsudana x alba hybrid clones recommended for river control purposes include, 'Aokautere' (NZ 1002), 'Hiwinui'(NZ 1130), and ‘Moutere'(NZ 1184). These clones have vigorous growth rates and develop wide-spreading fibrous root systems. The results from a study investigating fibrous root formation in selected tree and shrub willow clones suggested that 'Hiwinui' and 'Aokautere' were well suited to channel control work (Stace, 1988). ‘Moutere' was identified as a excellent general purpose clone.

The maintenance requirements of willows, particularly tree willows, usually involve rejuvenating trees by lopping and layering. Without regular maintenance, willows can become top heavy and begin to break apart. It is therefore important to cull trees which could cause future problems.

NATIVE PLANTS

Historically, the disregard of native plants for soil conservation has hinged on widespread convictions that natives are unsuited to colonising or pioneering roles and pose too many difficulties in nursery production and field establishment. Depending on site and situation however, a number of native species readily lend themselves to soil conservation.

Early work into the utilisation of native plants for soil conservation began when New Zealand botanist Leonard Cockayne published his ideas on native revegetation in the 'Lyttleton Times', more than 80 years ago. Since then the Forest Research Institute and the Soil Conservation Centre, Aokautere, have conducted many research projects involving native plants. As a result of this research, many organisations, including government departments and local bodies, are now involved in native revegetation projects.

Perhaps the most important distinction between soil conservation programmes using native species and those using exotic species, is that native revegetation programmes are usually motivated primarily by ecological considerations, whereas exotic tree planting is influenced more by economic forces. The contrasting differences are often marked in river improvement works. Exotic species are primarily used for checking erosion on riverbanks, whereas native species are used to enhance aesthetic and ecological values in more stable (harmonious) riparian environments.

A successful integration of economic and environmental forces in river management planning has been achieved recently under the Kaituna Catchment Control Scheme (Douglas pers. comm.) where both native and exotic species were deliberately selected for revegetating riparian areas of streams feeding into lake Rotorua. The incorporation of native shrubs in this scheme was a high priority because of their ‘natural' characteristics and ecological values. By contrast, rapid-growing, high quality timber species such as *Acacia melanoxylon, A. dealbata* and *Cupressus lusitanica,* were also included to provide a financial return within 30 years.

In terms of nutrient absorption or erosion control, some natives may not add much to a good sole of grass, but have the advantage of suppressing brush weeds. *Phormium tenax* (flax), *P. cookianum* (mountain flax) and *Cortaderia toetoe* (toetoe) for example, are excellent species for stabilising streambanks and suppressing weed growth, and are usually planted closest to the waterline in revegetation projects.

Short shrubby species of *Hebe, Pittosporum, Coprosma* and *Olearia* are suitable for planting on streambanks above the waterline. Many of these species also have good root stabilisation properties. Other useful species include *Leptospermum scoparium* (Manuka) and *Aristotelia serrata* (Wineberry). Larger tree species, including *Scheffiera digitata* (pate), *Sophora microphylla* (kowhai) and *Cordyline australis* (cabbage tree) could be planted in the remaining riparian areas for long term aesthetics, wildlife habitat, and stabilisation insurance. There is also an excellent opportunity to establish timber species such as *Podocarpus totara* in these fenced-off areas. Alternatively, fast-growing exotic tree species could be planted to provide financial returns within 30 years.

As mentioned above, relatively few native species can be regarded as early pioneers or colonisers on disturbed land. Native plants are poor competitors with exotic brushweeds and without good weed control lack establishment vigour. As a result, recolonisation by native species along retired streamside margins is often poor (Williamson et al. 1990). To succeed, native revegetation projects need to be comprehensive, with species selected to match microsites and attention paid to basic establishment, i.e., ground preparation, weed and pest control, and the exclusion of all livestock.

HERBACEOUS PLANTS

A dense grass cover can provide excellent protection against streambank erosion. To fulfil a soil-protective function however, grasses need to be tough and resilient. These two attributes are very important as they increase the plant's ability to reduce water speeds and tractive forces at the soil surface, and enhance plant survival.

Another important attribute of grass plants is their fibrous root systems. A grass plant has a number of major roots, each of which may have many primary, secondary, and tertiary branches. This fibrous root development enables a grass plant to counterbalance tractive forces generated by water on the leaves. The effectiveness of this fibrous root system is demonstrated by its resistance to being uprooted.

Phalaris aquatica ('Grasslands Maru' phalaris) is a sod-forming perennial which is well adapted to sites fluctuating between excessively dry and wet conditions. Unlike most other grasses, 'Grasslands Maru' will tolerate long periods of inundation. It has low seedling vigour, but once established will form a deep rhizomatous root system. 'Grasslands Maru' is considered to be very suitable for stream bank erosion control.

Phalaris arundinacea (reed canary grass) is a long-lived, summer-growing bunch grass which has had sporadic use in New Zealand because of its limited availability. Similar to 'Grasslands Maru', reed canary grass can tolerate inundation for up to two months and has an extensive rhizomatous root system. Reed canary grass is mostly propagated from turves or sods, but establishment by natural reseeding can occur in the absence of stock and birds.

Legumes are usually incorporated into grass mixtures to increase pasture productivity but are generally unsuitable for streambank protection work as they lack resilience and tend to be intolerant of poorly drained soils. However, a New Zealand bred rhizomatous legume, *Lotus pedunculatus* ('Grasslands Maku' lotus), is noted for its ability to tolerate seasonal flooding and wet, acid infertile soils. Although the establishment of *Lotus pedunculatus* is slow - usually 2-3 years - it can be improved by applying a fertiliser mixture specifically suited to legumes (Lambert et al. 1991).

Critical to the success of herbaceous plants in river improvement work is their management. At least two years should pass before consideration is given to grazing (Lambert et al. 1991). Any grazing thereafter should be strictly controlled. Spelling from grazing should be sufficiently long to allow full plant recovery. It is also important to exclude stock from riparian areas when soils are fully saturated as plants could suffer extensive damage - preferably cattle should be kept off at all times.

PLANT MATERIALS FOR COASTAL EROSION CONTROL

The transitional zone between a river and the sea is commonly difficult to revegetate because very few species are able to flourish in salty environments. Nevertheless, soil reinforcement by means of plants is an effective method for checking erosion on brackish water sites.

Careful planning and an appropriate selection of plant materials is critical to success of coastal erosion control. Usually, some form of temporary auxiliary protection is used to stabilise planting sites during the establishing stage of plant growth. Auxiliary protective measures range from the often unsightly placement of concrete blocks on coastal banks to more advanced engineering constructions.

A number of herbaceous plants are recommended for planting on these sites. Notable examples include *Agropyron elongatum, A. pugnens, A. junceiforme, Festuca arundinacea* ('Grasslands Roa' tall fescue), *F. rubra* (Chewings fescue), *Lolium perenne, Lotus tenius* and *Trifolium fragiferum* (strawberry clover). Species such as *Leptocarpus similis* (jointed rush), *Juncus maritimus, Plagianthus divaricatus, Phormium tenax* and *Cortaderia toetoe* are useful if the site is subject to periodic inundation.

Often it is necessary to interplant tree and shrub species among grass species to provide the ultimate erosion control. Among the most useful shrubs for such protection purposes are *Tamarix chinensis* (tamarisk), *Tamarix aphylla, Acacia (longifolia* var.) *sophorae, Coprosma acerosa* (sand coprosma), *Olearia solandri*, and *Salix* species. Native tree species that may be of value include *Metrosideros excelsa* (pohutakawa), *Griselinia littoralis* (broadleaf), *Corynocarpus laevigatus* (karaka), *Olearia paniculata* (akiraho), *Pittosporum crassifolium* (karo) and *Coprosma repens* (taupata).

CONCLUSIONS

The great success of vegetative control of river erosion in New Zealand indicates clearly that vegetation is both desirable and necessary in river training and bank protection work. Indeed, it is fair to say that river control planting, the foundation of at least 100 years of river improvement work, has largely restored the delicate balance between erosion processes and river stability that was transformed by man's destructive and exploitive activities.

Many plant materials useful for riverbank plantings are discussed in this paper. Together these versatile plants are well adapted to most ecological conditions in New Zealand.

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